4.7 TRANSFERRED FILMS

Several of the polished stainless steel disks exhibited opaque films after testing. A heavy mark was invariably visible after every saline test, while less noticeable films appeared after hyaluronic acid tests, and little or no film was visible after synovial fluid tests. Although some low-load tests tended to exhibit lighter films than some of the high-load test specimens, the load did not appear to have a significant effect on the appearance of these films.

Figure 4.49 shows the film that appeared on the stainless steel disk during test CS01, a high load buffered saline test. The photograph, which was taken at a magnification of 55X, shows the dark film where the cartilage specimen was in contact with this disk. The total sliding distance and contact region can be seen in this figure; the direction of sliding was left to right.

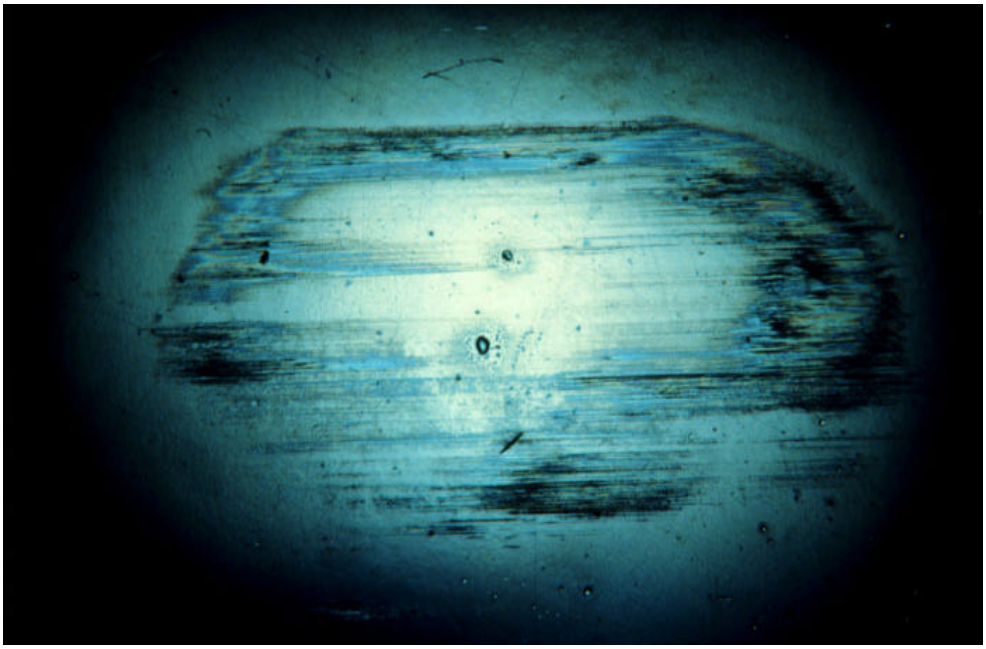

Figure 4.49: Stainless Steel Disk Surface After Saline Test

Figure 4.50 shows (at the same magnification) a similarly polished disk, which was used as the bottom specimen in test CS02, a high-load synovial fluid test. Although the film still appears on this disk, it is limited to the outer edges of the region of contact between the cartilage and the stainless steel. No visible film was transferred within the contact region.

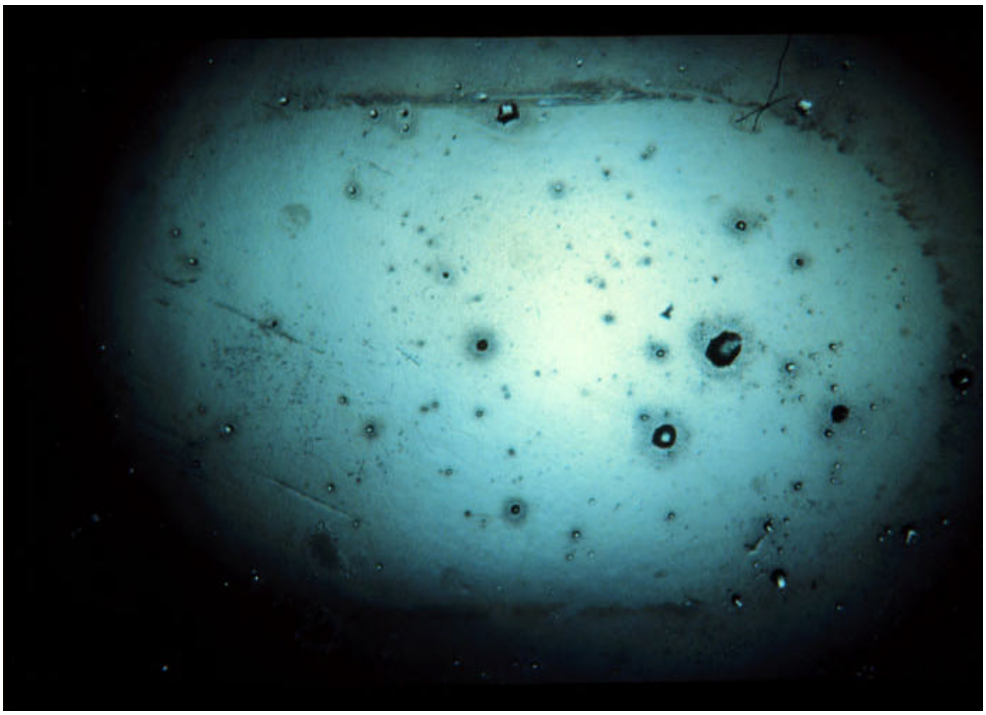

Figure 4.50: Stainless Steel Disk Surface After Synovial Fluid Test

While nearly all of the hyaluronic acid test specimens showed evidence of these films after testing, they tended in such cases to be less pronounced than those resulting from the saline tests. Figure 4.51 shows the stainless steel specimen from test CS06, a high-load hyaluronic acid test, at a magnification of 55X.

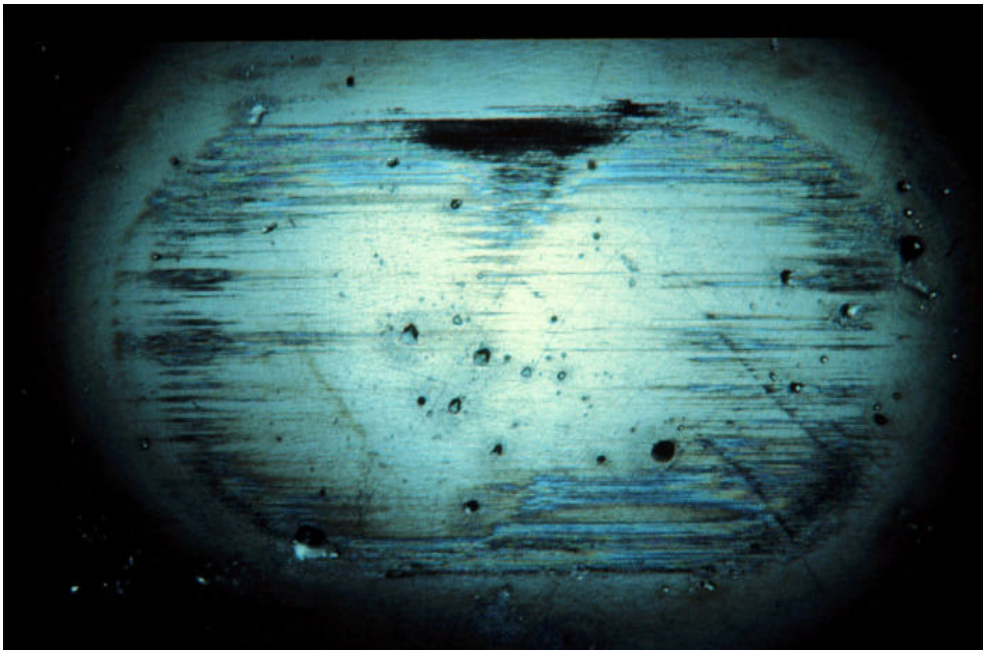

Figure 4.51: Stainless Steel Disk Surface After Hyaluronic Acid Test

Although the lubricant proved to be a statistically insignificant factor in determining the total measured cartilage wear, this variable was definitely an important factor in determining the appearance and quantity of these transferred films. With few exceptions, synovial fluid tests produced almost no visible transfer films on the stainless steel disks, while both buffered saline and hyaluronic acid produced the noticeable transfer films shown in the previous figures. These films remained after being rinsed vigorously with 5 mL of deionized water. If the material on the surface of the metal amounted to a comparable mass to that of the cartilage wear debris, the cartilage wear values determined using hydroxyproline analysis may have failed to reflect all of the wear debris that was formed during sliding. The wear analysis may have underestimated the amount of wear that actually occurred for the buffered saline and hyaluronic acid tests.

The nature of these films is also a question that has not yet been answered. Preliminary analysis using Fourier Transform Infrared analysis (FTIR) showed that these films do not simply consist of worn cartilage; they are composed of a completely different material, which has experienced a chemical change during sliding. Figure 4.52 shows an example of a spectrum obtained using FTIR analysis on a sample of unworn cartilage. In Figure 4.53, an FTIR spectrum of a worn cartilage specimen is shown.

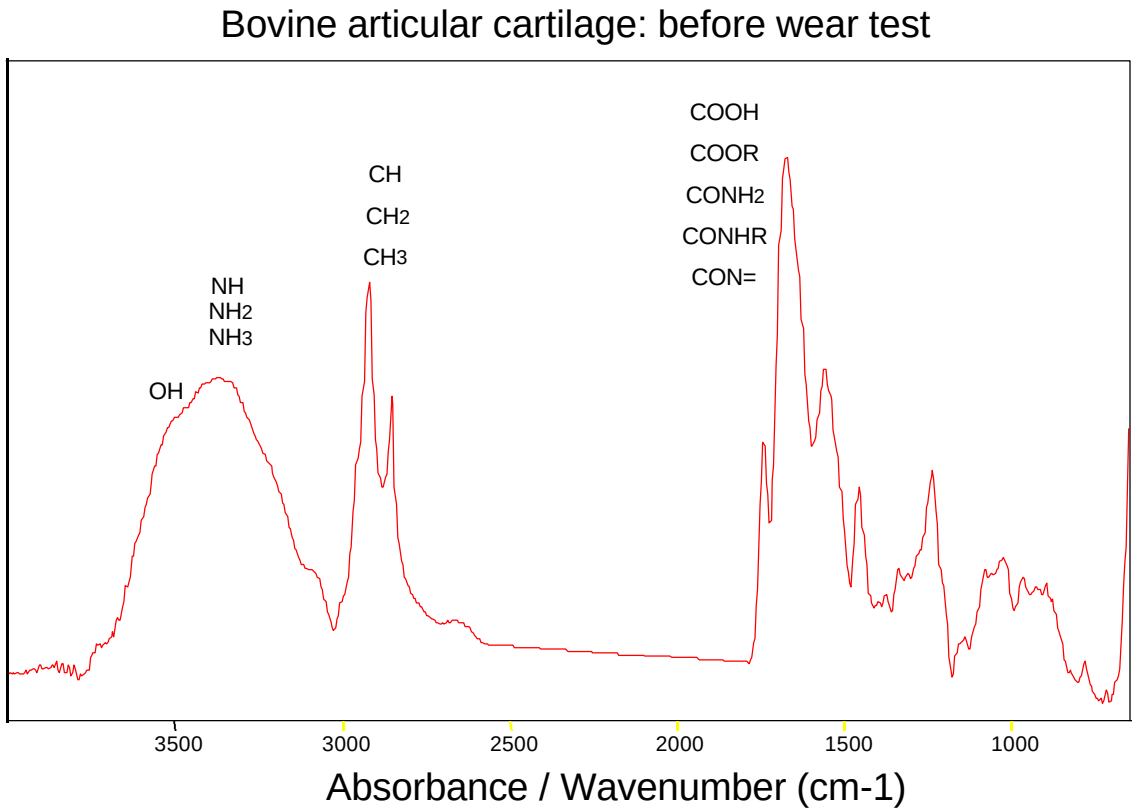

Figure 4.52: FTIR Analysis of Unworn Bovine Cartilage

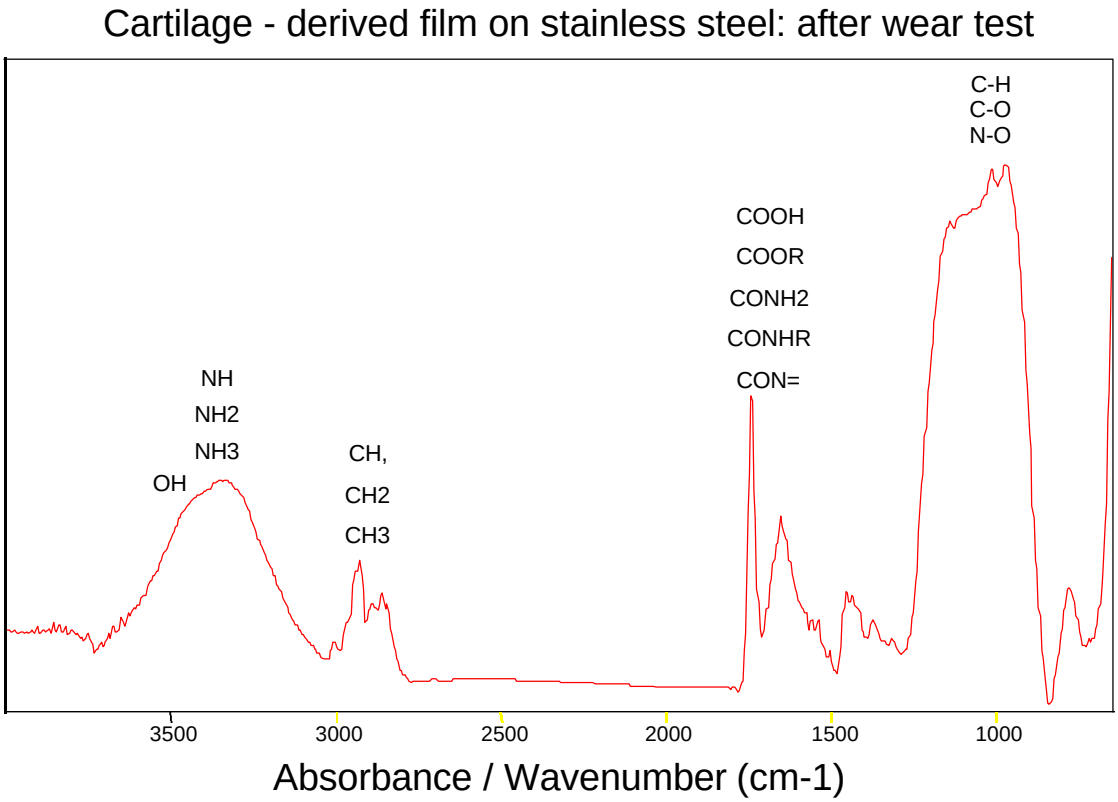

Figure 4.53: FTIR Analysis of Cartilage After Wear Test

The absorbance peaks shown in Figures 4.52 and 4.53 are not the same; this difference indicates that a chemical change has occurred in the cartilage during testing.

Figures 4.54 and 4.55 show FTIR spectra of synovial fluid before and after being used as a lubricant in a wear test, respectively.

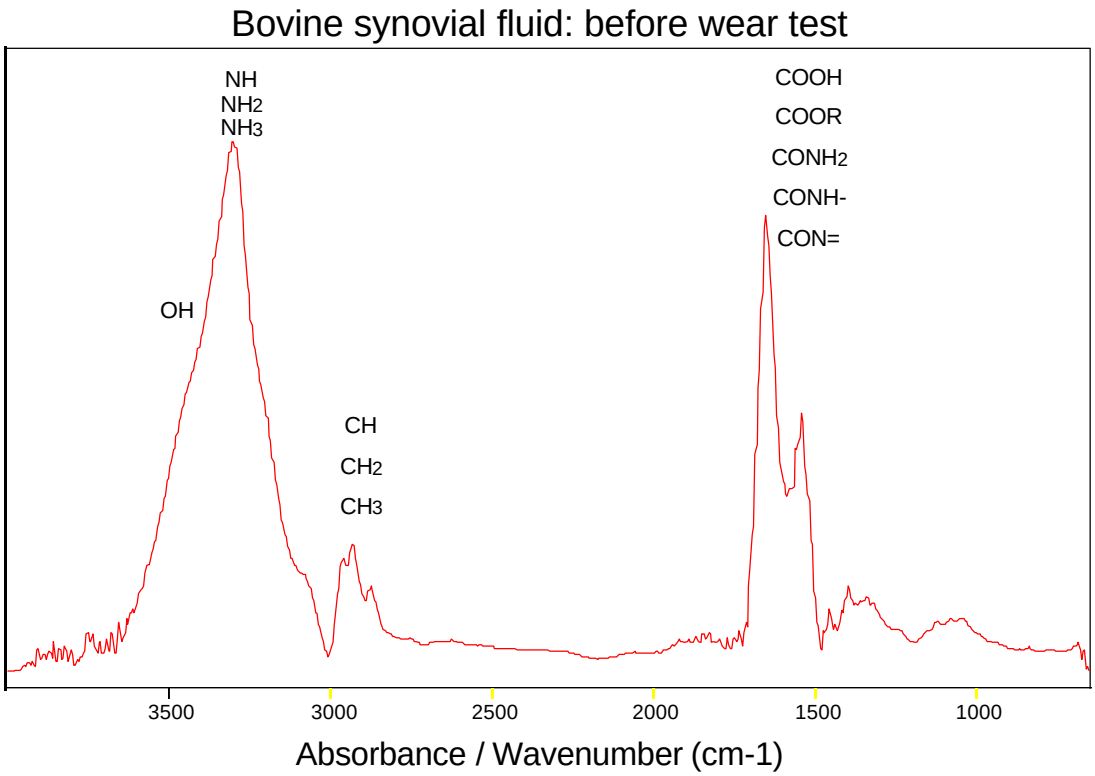

Figure 4.54: FTIR Analysis of Synovial Fluid Before Wear Test

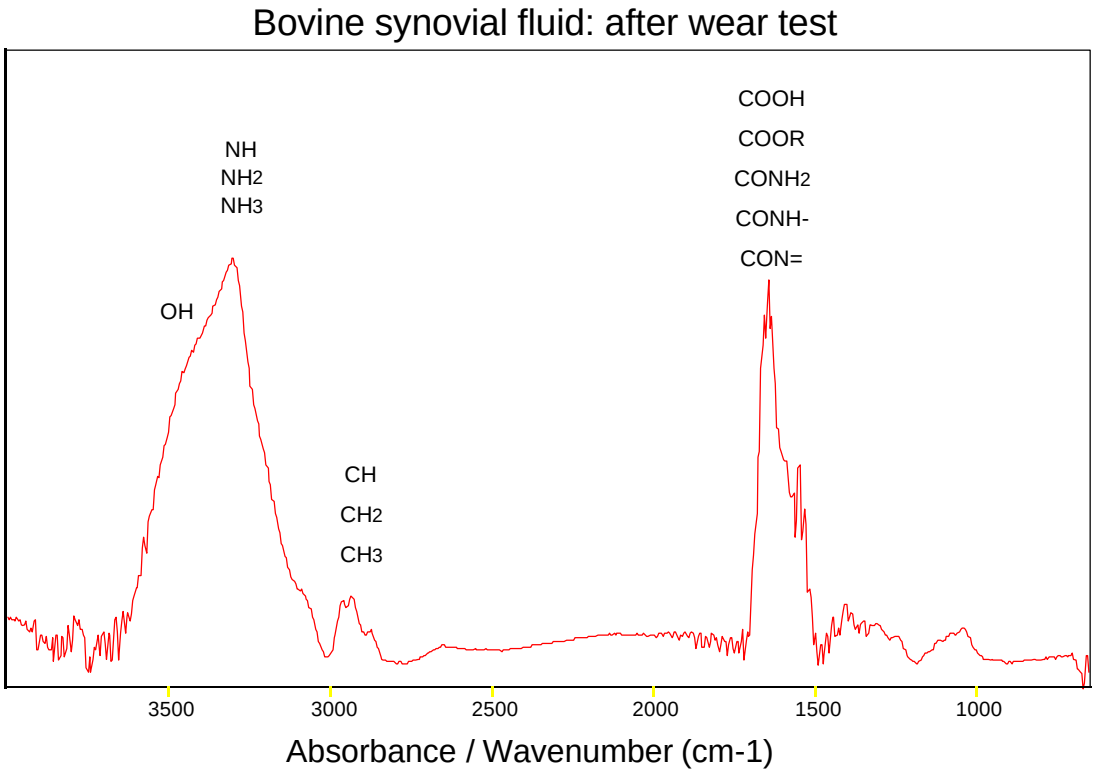

Figure 4.55: FTIR Analysis of Synovial Fluid After Wear Test

The FTIR spectra of the synovial fluid specimens exhibit similar absorbance peaks, indicating that the synovial fluid did not experience any detectable chemical changes during testing. Further FTIR analysis of cartilage, lubricants, and transferred films could help to answer this question.